
The X-Ray Optics for the High Angular Resolution Imager (HARI)

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Basic Parameters

Focal length (cm) 275

Max diameter (cm) 75

Min diameter (cm) 21

Max segment length (cm) 10

Min segment length (cm) 4.45

Baseline design

Shell thickness (cm) 0.2

Number of shells 68

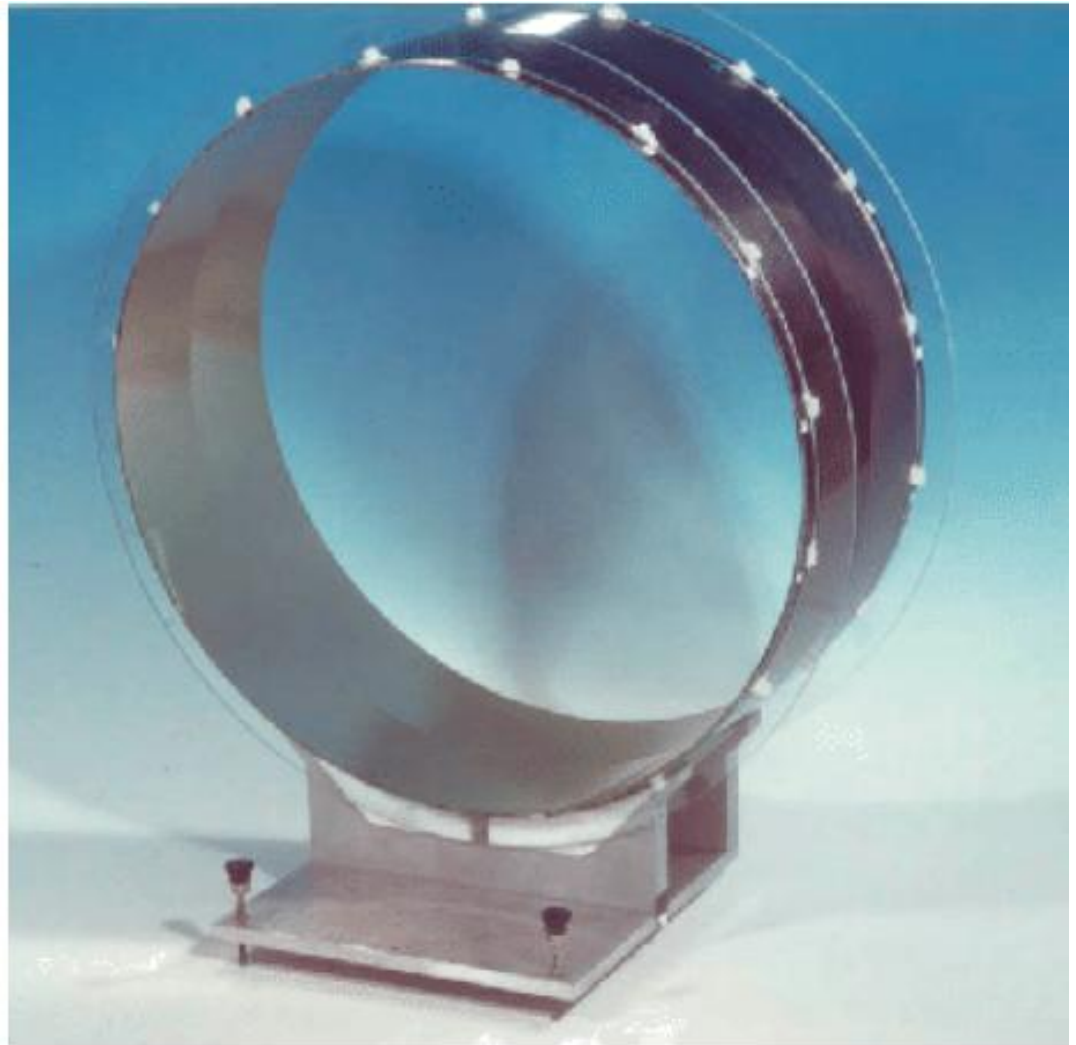
Goal Design

Shell thickness (cm) 0.1

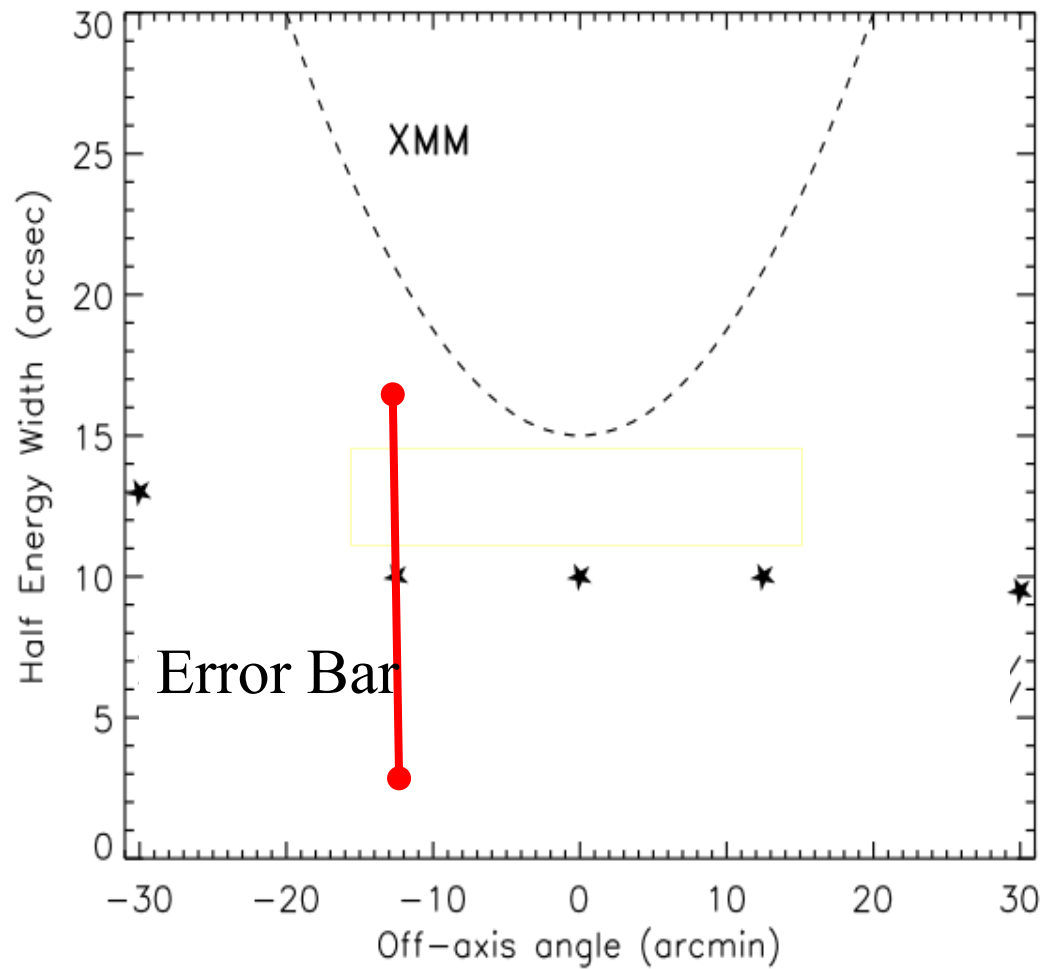
Number of shells 94

An Early Prototype was built at Brera

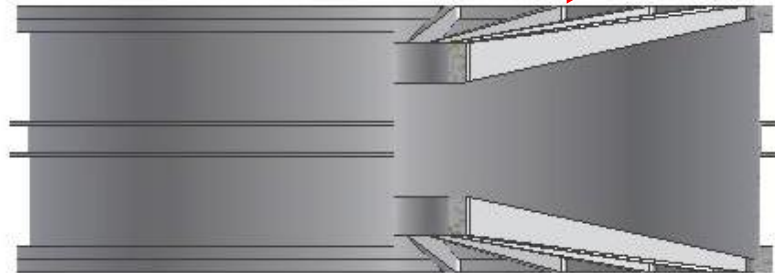
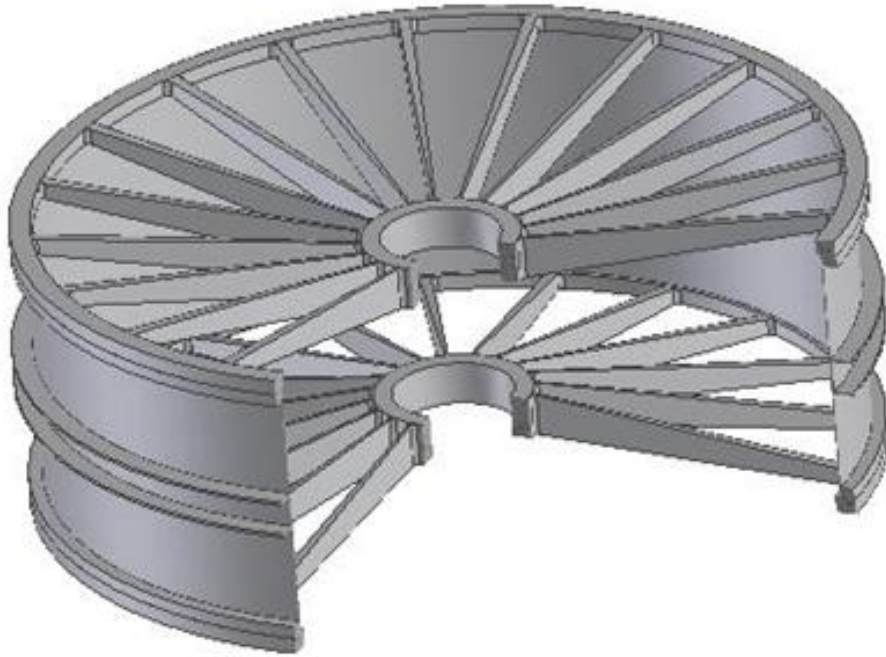
- 60-cm diameter
- 12-cm segment length
- 2-mm thick
- SiC



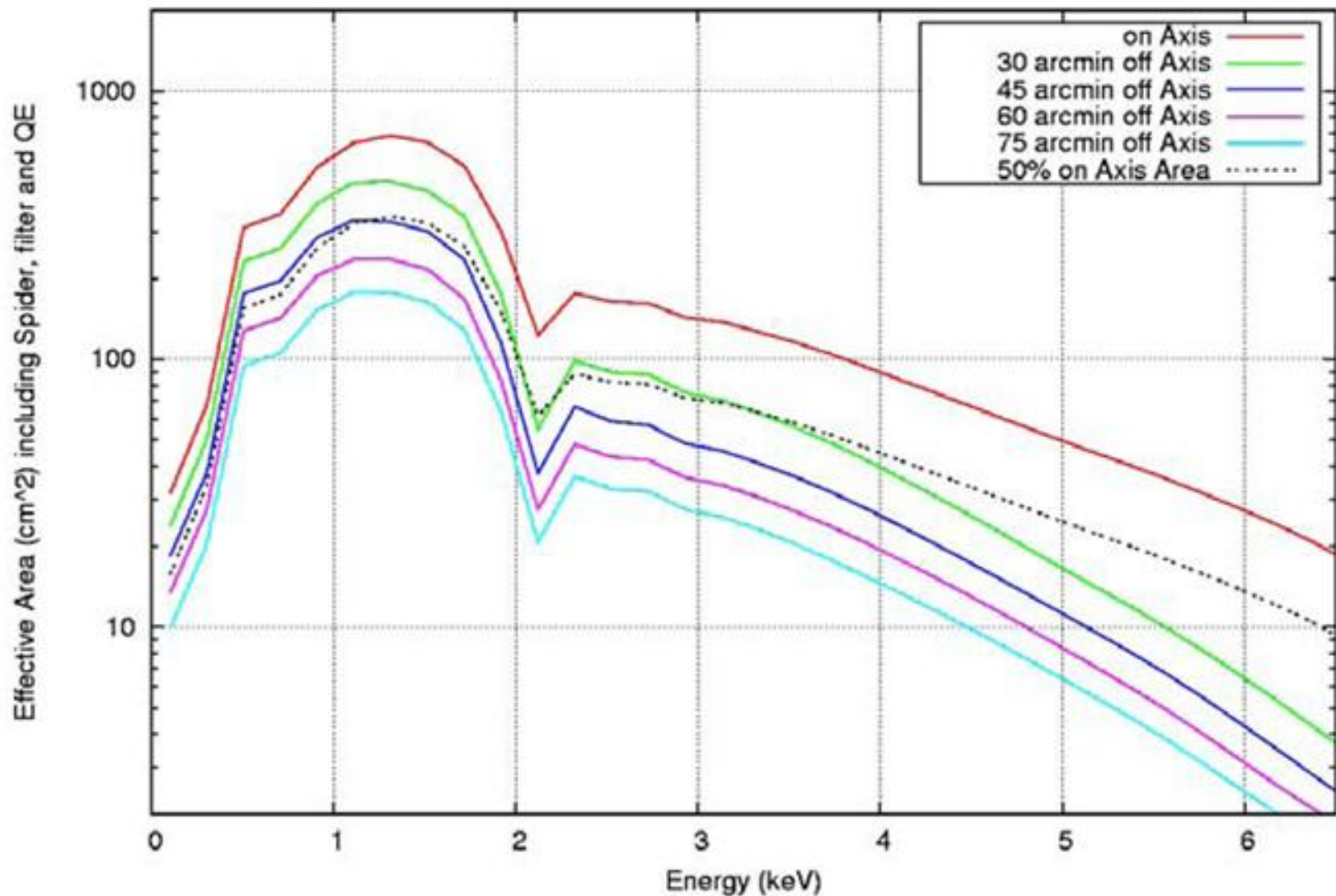
and X-Ray Tested at MSFC



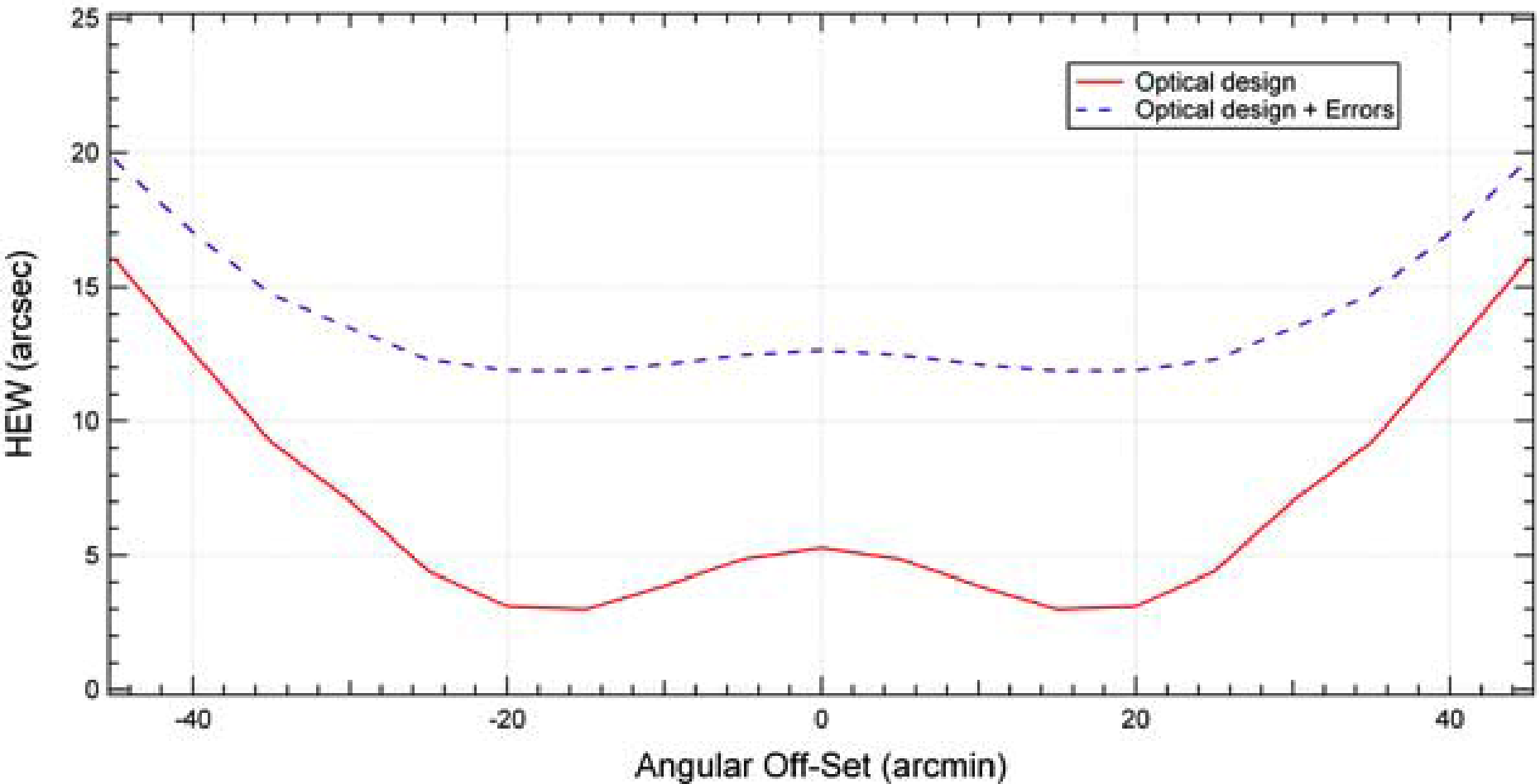
Housing – (EDGE)



Effective Area vs Energy and Off-axis Angle



Baseline Design – HEW vs θ



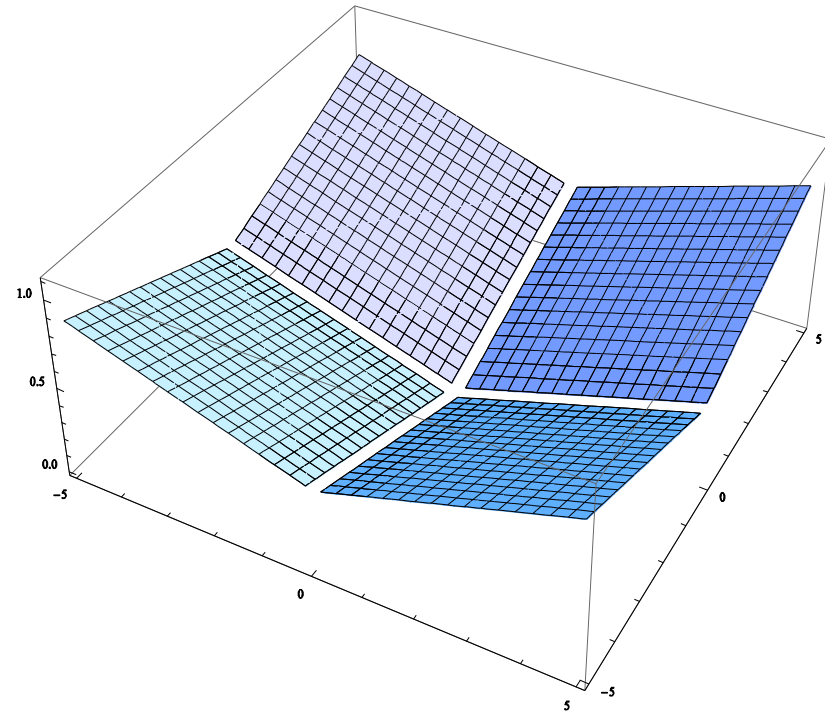
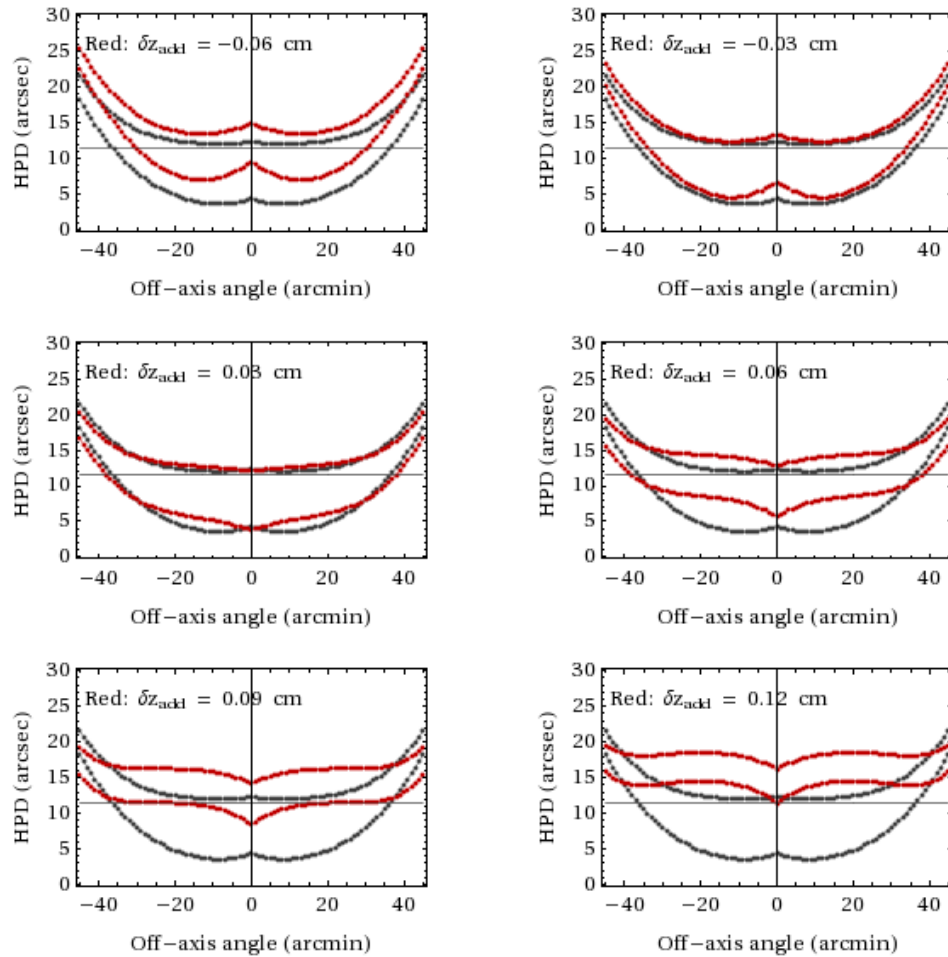
Design optimization

- The approach perturbs a design based on Wolter-I optics and minimizes equations of the generic form:

$$\sigma^2(\theta, \varphi) \approx a + 2 b \delta z + c \delta z^2 + 2 d \tan \theta_{CCD} + 2 e \delta z \tan \theta_{CCD} + f \tan^2 \theta_{CCD} + \dots$$

- The parameters a,b,c,... are coefficients of the expansion for the rms blur and depend on other familiar variables of the optics.
- The functional forms of these parameters may be derived analytically for single and nested Wolter-I shells.

Study of detector offsets and tilts



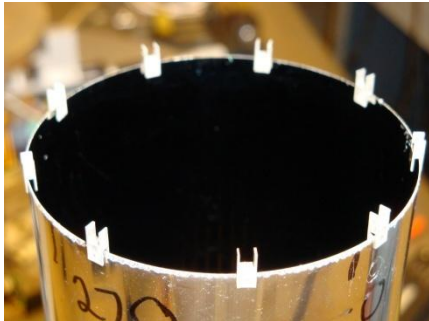
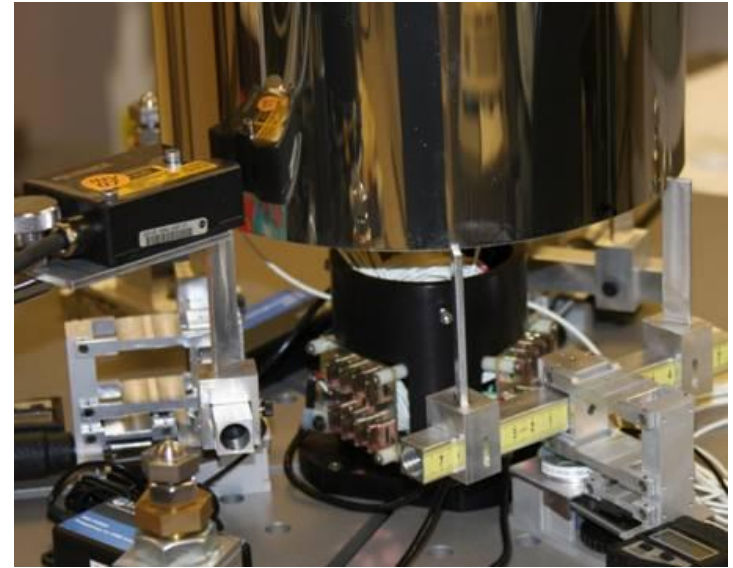
The Design Approach is not Optimum (Yet)

- **One is still designing the detector-optics combination in a somewhat ad-hoc way. Our goal is to be able to design HARI around the scientific performance and let the latter guide the system parameters.**
- **This does not mean that the current design is “bad”!**
- **But we need an agreed upon optimization criterion!**

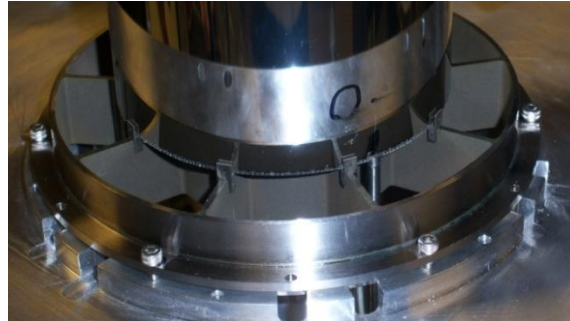
THIS IS YOUR HOMEWORK PROBLEM

Advances in mounting approaches

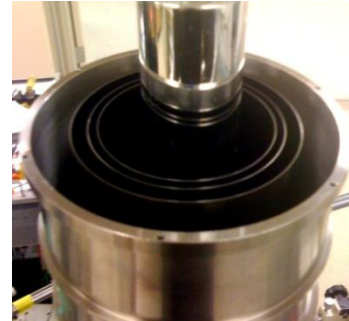
- High-precision non-contact sensors monitor the circularity of the shell at 4 axial positions.
- Actuators position the shell with submicron accuracy.



Mounting clips



Shell installed above a spider

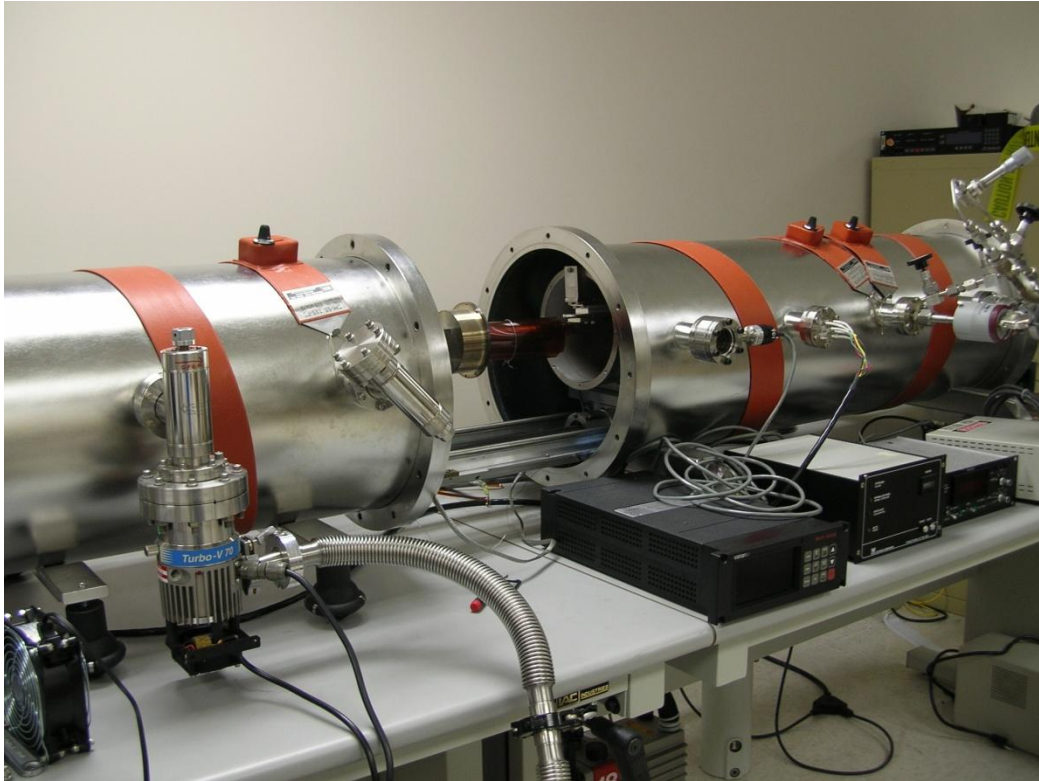


*Module before the
top spider is
installed*



*module at the
station*

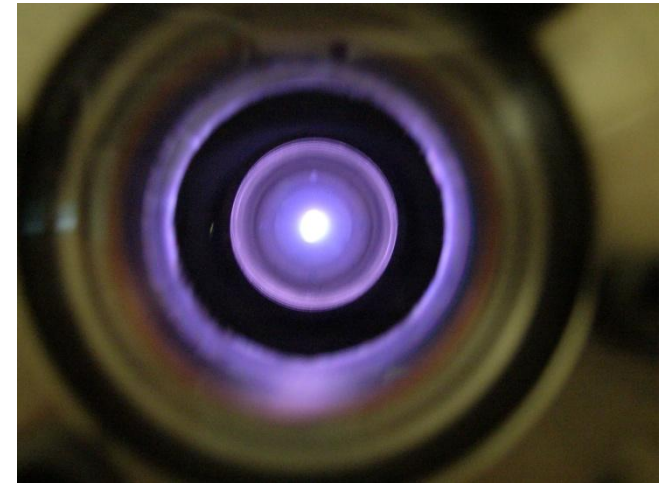
Selective deposition to correct errors



RF sputtering chamber



Typical coating mask



RF plasma during coating